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ABSTRACT

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Analysis of selected cognitive abilities and other factors associated with achievement in a biology preparatory course and beyond at an urban community college.

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ABSTRACT

This study was undertaken to determine whether a biology preparatory course, given at an urban community college, was helping students to develop the proper skills and background necessary for them to successfully complete follow-up courses in biology. From this case study, it was discovered that only 16% of the initial group of preparatory students enrolled in, and passed a follow-up biology class in either anatomy and physiology, or general biology. Examination of the preparatory group, using discriminant analysis ascertained that mathematics score was the principle discriminator between pass/fail groups. A step-wise multiple regression analysis of the variables explaining the preparatory grade showed that mathematics score, reading score, and type of high school degree explained 33% of the variance. Of the students who did pass the preparatory course and enrolled in a follow-up biology class, their preparatory grade was a good predictor of their achievement (measured by follow-up course grade), as determined by multiple regression.

Analysis of selected cognitive abilities and other factors associated with achievement in a biology preparatory course and beyond at an urban community college.

Introduction

Many institutions of higher learning have made a commitment to educational opportunities for all interested individuals. Thus, open admissions programs were established at these branches beginning in the late 1960's.

Since the inception of open enrollment, most of the community colleges have been inundated with large numbers of underprepared students. These individuals come from a variety of ethnic backgrounds. Many of them are foreign born and have difficulties with the English language. Others are products of school systems within which they have not mastered basic skills in reading, writing, or mathematics. Some have completed high school by attending an alterative high school degree program (GED). These students lack many of the fundamental skills that are expected of them in order to perform college level work.

This situation is not unique to the community colleges, and exists in varying degrees in the senior institutions as well. In order to deal with these problems at an urban community college, various remedial, as well as preparatory courses have been instituted.

Historical perspective

A review of twenty junior college remedial programs by Roueche (1967) concluded that their effects on students' subsequent educational accomplishments is questionable. A further study by Losak (1969) at Miami-Dade Junior College also showed

that students receiving remediation did not perform any better than students who had not taken remedial courses. Shoan (1972) randomly selected students to take remedial English at a community college. He found that those taking the remedial course had a modest increase in performance in subsequent courses. However, the remedial course had no effect upon student satisfaction or persistence in the subject. At Bronx Community College (1979) a probationary workshop (PWP-99) was analyzed to determine whether it improved the performance of probationary students. It was determined that the course was in need of revision since there was no significant relationship found between participation in the course and subsequent student performance.

According to McDermott, Piternick, and Rosenquist (1980), underprepared students not only lack a large body of knowledge, but also do not possess the reasoning skills necessary for acquiring scientific concepts. Therefore, they lack an understanding of basic biological concepts and the ability to apply them to appropriate situations. In fact, McDermott, et al., say that if students' reasoning skills are not sufficiently developed, it may not be feasible to try to teach them scientific material because they do not have the capacity to use the types of specific reasoning needed to understand sciences. In addition, these investigators believe that development of reasoning skills must be coupled with particular subject matter since transfer of reasoning skills by students from one context to another is believed to be minimal. Hands-on or concrete experiences in biology are considered to be essential for development of reasoning skills.

A course of instruction, according to McDermott, et al., should include emphasis on the laboratory, stress reasoning, the role of examinations and homework, and progressively increase student challenges.

Tomlinson and Tomlinson (1975), at the University of California at Riverside, attempted to promote students' skills foundations for later transfer to independent science reading. The course concentrated upon methods and materials of the intro-biology course for majors. The adjunct course was a non-credit, eight week course which met three times a week. Special skills were developed for the reading and studying of scientific materials. These skills were utilized for understanding the lectures and textbooks of the intro-biology course. The adjunct course, taught along with the intro-biology course, stressed skills such as surveying and constructing an overview map (conceptual framework), analyzing text material for comprehension, developing vocabulary through analysis of Greek and Roman roots, understanding diagrams and graphs, and developing self-questioning skills. Study skills such as concentration and remembering techniques, and effective test-taking strategies were also taught. Student satisfaction with the adjunct course was high, but transfer of skills to subsequent courses was not determined.

A study utilizing diagnostic testing and prescription for students was undertaken by Yeany and Adams (1981). This investigation demonstrated that the practice was a way of providing effective remediation to biology students. Diagnostic tests were taken by students, and immediate feedback was available to them. A remedial

guide in written form explained why certain responses on the diagnostic test were correct or incorrect.

Yeany, et al. (1981), believe that the reason why diagnostic/prescription (dp) techniques have not caught on in colleges, despite effectiveness, is due to the fact that many professors resist alterations in instructional procedures. The investigators state that learning or media centers could be utilized to implement dp systems on a supplemental basis.

A four year study of a community college preparatory chemistry course was performed by Ozsogomonyan (1978) at three colleges of the San Mateo College District in California. The rationale for a preparatory course at the college level was based on the assumption that one can quickly provide the necessary experiences and cognitive skills not learned previously so that students will be prepared to perform college level science work.

These students were followed by Ozsogomonyan to determine their success in general chemistry. Although 60% of the preparatory course students completed the course, only 25% enrolled in general chemistry. Apparently, the other students realized that chemistry was not for them. The preparatory grades were found to be a reliable indicator of general chemistry grades. Thus, the rationale for providing a preparatory course in chemistry was supported in this study; however, one must take note of the high attrition rate.

In summary, it has been determined that there are various methods available for use in preparatory and remedial work. Some of these techniques have been incorporated into the preparatory course under study. The purpose of this investigation was to analyze the effectiveness of the preparatory biology course in its ability to

provide the cognitive skills necessary to perform successfully in subsequent biology courses.

Background

Students who wish to enroll in general biology or anatomy and physiology courses, and who demonstrate deficiencies in mathematics, reading or writing skills on standardized entrance examinations (freshman skills assessment tests), are required to first successfully complete a biology preparatory course at the community college studied. The course is for no credit and meets four hours per week during a 12 week module and eight hours per week during a six week module. The course combines discussions, demonstrations, and laboratory experiences. The workbook chosen for this course was selected because it integrates basic skills such as enhancement of vocabulary, reading comprehension, library techniques, mathematical computations, use of the calculator, graphing with interpolation and extrapolation, as well as other activities. The development of these skills is believed to be essential for achievement in any science course.

Problem

Is this preparatory course doing what it was intended to do? Is it preparing students who show deficiencies in essential skills to proceed into more difficult and technical science classes? In addition, on what basis can pass/fail preparatory groups be distinguished? Of the students who do complete the preparatory course, what variables are associated with their successful completion of a follow-up biology class?

Hypotheses

- H₁ There will be a significant positive relationship between reading score and achievement in the biology preparatory course as measured by course grades.
- H₂ There will be a significant positive relationship between mathematical ability and achievement in the biology preparatory course as measured by course grades.
- H₃ There will be a significant positive relationship between years in the United States and achievement in the biology preparatory course as measured by course grades.
- H₄ Students with a regular high school degree will differ significantly from students with a GED degree in achievement in the biology preparatory course as measured by course grades.
- H₅ As a group, passing students in the preparatory course can be discriminated from failing students in the preparatory course on the basis of their CUNY mathematics score.
- H₆ As a group, passing students in the preparatory course can be discriminated from failing students in the preparatory course on the basis of their scaled reading scores.
- H₇ As a group, passing students in the preparatory course can be discriminated from failing students in the preparatory course on the basis of their writing score.

H₈ For those students taking the follow-up biology courses, the biology preparatory grade will be the variable which best explains achievement as measured by the initial biology course grade.

Procedures and experimental design

The investigation undertaken was of ex-post facto, non-experimental design. One full academic year of data was collected including the semesters beginning Fall 1984, Winter 1985, Spring 1985, and Summer 1985, for students enrolled in the Biology Preparatory Course (Biology 10) and General Biology (Biology 13), as well as Anatomy and Physiology (Biology 11). The college runs on a 12 week-6 week, 12 week-6 week basis. The two mini-semesters represent winter and summer sessions. A t-test was performed to determine whether the Biology Preparatory Course grades for the fall and winter semesters were significantly different. They were found not to be significantly different ($p \leq 0.05$).

A. Data collection

Data was requested from the Instructional Computing Center at the college and was supplemented by printouts from the Office of the Dean of Students, as well as Registrar files. Information gathered, included students' reading, mathematical, and writing skills scores. The reading scores were determined using the Descriptive Test for Language Skills (DTLS), and the mathematics scores were from the City University of New York Mathematics Skills Test. Writing skills were judged by teams of faculty members using student essay samples. It was also determined on the basis of freshman skills scores, whether

students taking the Biology Preparatory Course were actually required by the college to do so. (Students exhibiting minimum proficiencies were required to enroll in the preparatory course, but other students might also enroll.)

A difficulty with the reading scores was that six different versions of the DTLS were administered to students. In order to equate scores, the actual scores were converted into scaled scores before they were utilized in statistical procedures. Other independent variables utilized were; type of secondary school diploma (regular or GED), number of years in the United States, sex, age, and birthplace (U.S. or foreign born).

The students' grades in the Biology Preparatory Course were tabulated. Analysis was performed to see how many of the preparatory students enrolled in the follow-up General Biology (Biology 13) and Anatomy and Physiology (Biology 11) courses. It was further determined how successful the students were who enrolled in the follow-up courses.

B. Data analysis

All hypotheses were tested at the 0.05 level of significance.

One-way ANOVA's were performed between preparatory course grade and the independent variables, and between follow-up biology grades and the independent variables.

The biology preparatory students were divided into pass and fail groups and discriminant analyses were performed to determine which variables best discriminate between groups. The same analysis was performed for the follow-up biology courses (11/13) pass and fail groups.

Multiple regressions were performed with the dependent variable being preparatory grade and the independent variables, and with the dependent variable, initial follow-up biology grade and the independent variables.

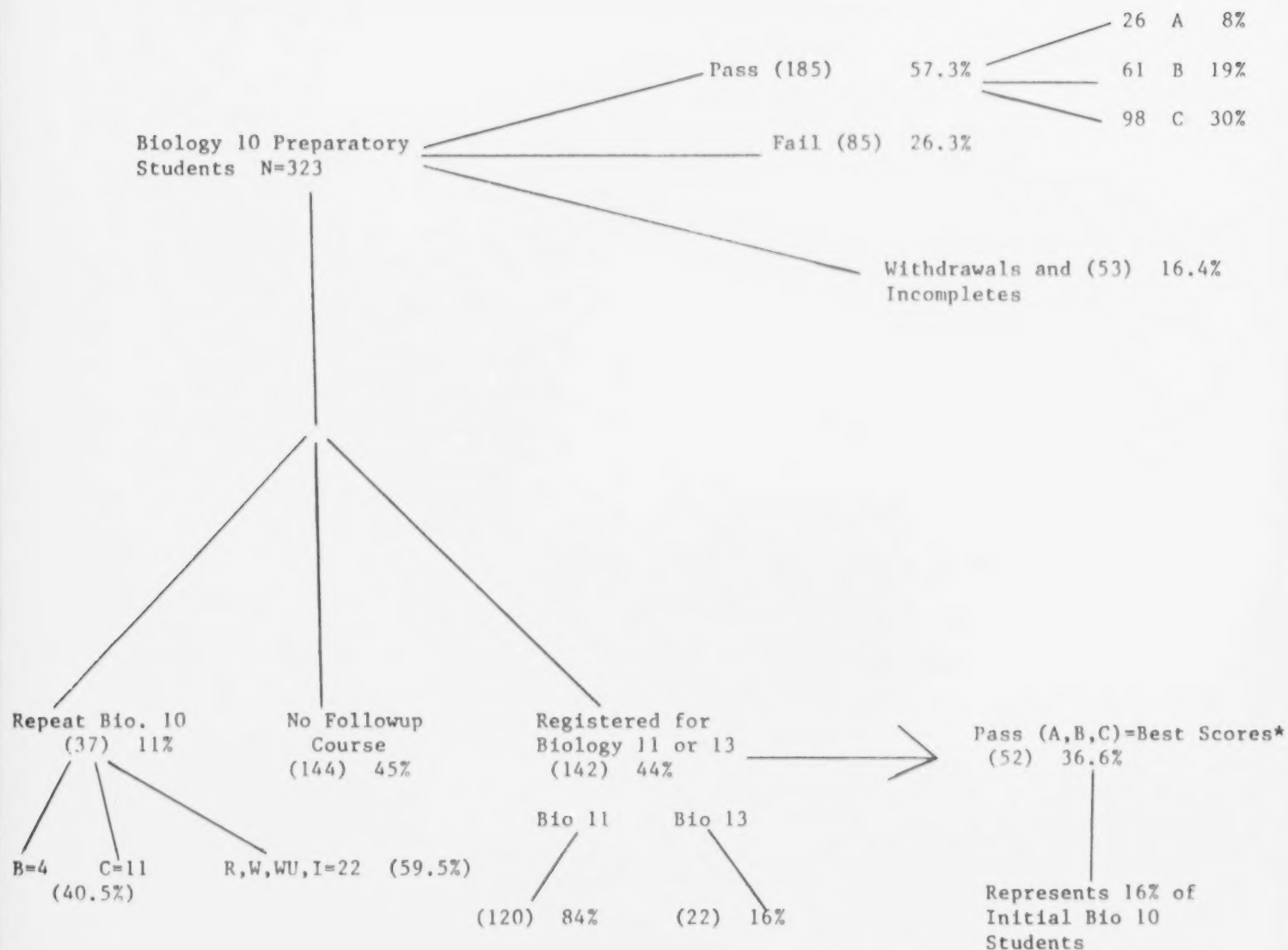
C. Student characteristics

Three hundred and twenty three (323) students enrolled in the biology preparatory course during the period under study. They were predominantly female (88%), 45% were born in the United States, while 55% were foreign born. In the latter group, 18% were Haitian, 12% Jamaican, 10% Virgin Islanders (various islands), and 5% Guyanans, with additional smaller percentages of other nationalities. Some 41% of the students have been in the United States for 10 years or less. In the total group of students, 70% had graduated from high school while 29% had taken high school equivalency degrees (GED). A few students had previously attended college (1%).

Results

Analysis of the Biology Preparatory Course (Biology 10) during the Fall, 1984 through Summer, 1985 determined that 185 students (57%) passed the course while 138 students (43%) either failed or withdrew. A further study of these students showed that 37 (11%) repeated the preparatory course, 144 (45%) took no follow-up course, and 142 (44%) enrolled in general biology or anatomy and physiology courses. Of the 142 students enrolled in follow-up courses, 52 students (37%) passed with grades of C or higher. This represented 16% of the original biology preparatory population. (See Table I)

TABLE I - SUMMARY FLOW CHART - FOLLOWUP OF PREPARATORY STUDENTS (Biology 10)



* Includes students who may have achieved grade after repeating course

One-way analysis of variance showed that mathematics score, reading score, and type of high school degree were significantly related to passing or failing Biology 10, the preparatory course. The results were confirmed in later analysis.

Table II-Summary Table of One-Way Analysis of Variance Between Pass and Fail Groups in Biology 10 for Reading Score

Source	<u>df</u>	Sum of squares	Mean squares	<u>F</u> ratio
Between groups	1	391.97	391.97	14.68 *
Within groups	268	7158.29	26.71	
Total	269	7550.26		

* $p \leq 0.0002$

Table III-Summary Table of One-Way Analysis of Variance Between Pass and Fail Groups in Biology 10 for Type of High School Degree

Source	df	Sum of squares	Mean squares	<u>F</u> ratio
Between groups	1	1.4781	1.4781	4.237 *
Within groups	268	93.4875	0.3488	
Total	269	94.9656		

* $p \leq 0.040$

Table IV-Summary Table of One-Way Analysis of Variance Between
Pass and Fail Groups in Biology 10 for Mathematics Score

Source	<u>df</u>	Sum of squares	Mean squares	<u>F</u> ratio
Between groups	1	1420.84	1420.84	23.95 *
Within groups	268	15902.12	59.34	
Total	269	17322.96		

* $p \leq 0.000$

A stepwise discriminant analysis for pass and fail groups in the preparatory course pointed to mathematics as being the primary discriminating variable. This result was not surprising since a similar study (Biermann, 1985) exhibited mathematics as being the best discriminator of pass/fail for an upper level biology group from the same college. Mathematics was followed by reading score, type of high school degree, and birthplace.

Table V - Order of Variables Stepwise Discriminant Analysis
Pass and Fail Preparatory (Biology 10 Groups)

Variable	Wilks' lambda	Significance
1. Mathematics	0.917979	0.0000
2. Reading Scaled Score	0.882754	0.0000
3. HS - GED Degree	0.869333	0.0000
4. Birthplace	0.861778	0.0000

Note. Nonsignificant variables were not included in this table.

Table VI - Classification of Pass and Fail Groups in Stepwise Analysis

Actual group		Number of cases	Predicted group membership	
			1	2
1	<u>N</u>	85	60	25
	%		70.6%	29.4%
2	<u>N</u>	185	64	121
	%		34.6%	65.4%

Note. Percent correctly classified 67.04%. Actual group 1 = Fail and actual group 2 = Pass.
One discriminant function was generated with a canonical correlation of 0.37 and an eigen value of 0.16.

A stepwise multiple regression analysis of the preparatory course grade using achievement and demographic variables determined that the first three variables (mathematics, reading, and type of high school degree) explained 33% of the variance of the preparatory grade. A good deal of the variance remained unexplained.

Table VII Summary of Stepwise Multiple Regression Analysis of Biology 10 Grade Using Achievement and Demographic Variables

Variable	Simple r	Beta	Standard error of B	F ratio
Mathematics	0.31	0.29	0.01	28.88*
Reading score	0.14	0.13	0.02	3.81**
HS-GED degree	-0.10	-0.10	0.15	2.08***
Age	-0.06	-0.07	0.01	1.33
Years in US	-0.08	-0.05	0.11	0.42
Writing Score	0.09	0.04	0.11	0.32
Sex	-0.01	-0.03	0.25	0.33
Birthplace	0.05	0.02	0.04	0.07

Multiple $R^2 = 0.33$

* $p \leq .001$

** $p \leq .025$

*** $p \leq .05$

A comparison of preparatory students for high school and GED groups was performed. It was shown that the average age of GED students is 29.5 years, which is, on the average, eight years older than the high school group. The proportions of male and female students in the two groups is approximately the same. Mathematics, reading score, and writing scores are higher for the GED group. In the GED group, 59% passed the preparatory course as compared with 55% of the high school group. When comparing the two groups that proceeded to take the follow-up biology courses, 41% of the GED group passed, while only 17% of the high school group passed. Upon comparing the two groups for the best follow-up biology grade attained, only 29% of the high school group passed, while 51% of the GED group passed. Another interesting finding was that 60% of the GED group was foreign born as compared to 53% of the high school group.

A stepwise multiple regression of the follow-up biology course grade using achievement and demographics displayed the biology preparatory grade as being able to explain some of the variance in the dependent variable, along with age and mathematics score.

Table VIII-Summary of Stepwise Multiple Regression Analysis of
Follow-up Biology (11/13) Initial Grade Using Achievement and
Demographic Variables

Variable	Simple $\underline{r}$	Beta	Standard error of B	$\underline{F}$ ratio
Biology 10 Grade	0.48	0.45	0.04	73.74*
Age	0.08	0.12	0.01	4.55**
Mathematics	0.24	0.08	0.01	2.38***
Sex	-0.05	-0.04	0.17	0.59
Years in US	-0.06	-0.08	0.01	1.30
Writing Score	0.08	0.04	0.07	0.56
Birthplace	0.04	-0.03	0.02	0.32
HS - GED Degree	-0.07	-0.01	0.10	0.05
Reading score	0.08	0.01	0.01	0.02

Multiple $\underline{R}^2 = 0.24$

* $p \leq .001$

** $p \leq .01$

*** $p \leq .10$

A further stepwise multiple regression analysis was performed to determine the variables which explain the best follow-up score. The analysis showed that the preparatory course grade and the initial follow-up biology course grade explained 77% of the variance. Students appear to be behaving consistently.

Table IX - Summary of Stepwise Multiple Regression Analysis of Follow-up Biology (11/13) Best Grade Using Achievement and Demographic Variables

Biology 11/13 initial grade	0.87	0.80	0.03	672.76*
Biology 10 grade	0.53	0.14	0.03	19.63*
Sex	-0.08	-0.04	0.10	1.84
Birthplace	0.02	-0.03	0.01	1.12
HS or GED	-0.06	0.02	0.06	0.49
Years in US	-0.06	-0.02	0.00	0.41
Age	0.05	0.02	0.00	0.27
Writing	0.09	0.01	0.05	0.08
Mathematics	0.24	0.01	0.00	0.03
Reading Score	0.08	0.01	0.01	0.02

Multiple $R^2=0.77$

* $p \leq .001$

Note. If the multiple regression is performed without the first two variables then mathematics becomes the variable explaining 7% of the variance.

Conclusions and implications

The data seems to show that mathematics score and reading score are significantly and positively related to achievement in the biology preparatory course, while writing score is not. GED graduates appear to perform better in the preparatory and follow-up biology courses than do high school graduates. The discriminant analysis points to mathematics score as the variable which best discriminates between pass/fail preparatory groups. The reading score is also a significant discriminator, but not the writing score. For those students who go

on to take the follow-up biology course, the preparatory grade is the best predictor of the follow-up course grade.

In a study of pre-nursing and nursing students at the same community college, Biermann (1985) found that the mathematics score was the variable which best predicted acceptance into the nursing program. Mathematics exhibited itself as an important variable in this study as well. It may be that analytical reasoning ability (as shown by mathematics scores) is a necessary prerequisite for many science related curricula. Students entering the nursing program must engage in superior work in three science-related courses (biology, chemistry, and psychology) in order to be accepted into the program.

One conclusion that is ultimately reached in the study is that the preparatory course, as given at this time, does not appear to be preparing many of the initially enrolled preparatory students to continue into follow-up courses. Only 142 students (44%) registered for the follow-up courses (most of them registered in anatomy and physiology). Another 144 students took no follow-up courses in biology at all. They seemed to discover that biology was not for them. Of the preparatory students who passed the follow-up biology courses (52 students), about half of these students were not required to enroll in a biology preparatory course at all. They may have enrolled because they felt they needed some extra help, or a refresher course before entering the mainstream courses in biology.

Discussion

The initial problem stated earlier, asked whether the biology preparatory course was preparing students who showed deficiencies in

essential skills so that they may proceed into more difficult and demanding biology classes. The findings illustrate that only a small group of the initial population succeeded. With this group, the biology preparatory course might have contributed to their preparation for the follow-up biology classes.

In order to enhance success (as measured by course grades) in biology courses, biology educators should realize that a strong analytical background in students seems to be indicated. It may be that students ought to take all their remedial or preliminary mathematics courses before enrolling in biology classes. Even though the biology preparatory course itself entailed a great deal of analytical reasoning, the course seemed unable to bring many up to par in required skills. There are many academic short-comings which students have accumulated over many years. Perhaps a mastery learning type of approach could be adopted to enhance skill development. This technique seems to work well with underprepared students.

In addition, fresh approaches to teaching preparatory biology courses may have to be attempted in the future to help poorly prepared students. The supplementary diagnostic prescription technique employed by Yeany, et al. (1981) might be applicable. A more flexible, modular approach to teaching biology on all levels might be indicated. The ultimate goal of the educator is obviously the success of their students despite their possible initial handicaps.

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